# EXPERIMENT - II

## FAMILIRISATION WITH SIGNAL GENERATOR, OSCILLOSCOPE AND STUDIES ON RC, CR AND RL CIRCUITS

**SEPTEMBER 29**

**Introduction to Electronics Lab (EC29003)**

**Report by: Sunanda Mandal**

***Objective :*** *Through this experiment, we get familiarized with frequency response of different circuit as R-C, C-R, R-L and L-R and how to use them as voltage dividers and frequency filters.*

## Part -I: R-C low pass filter

- Aim of the Experiment: To use R-C circuit as a low-pass filter and to observe its frequency response and phase response characteristics.

- Theory:

Input voltage of fixed magnitude $V_{in}$ (rms) is fed into simple series-RC circuit and output is taken from across the capacitor.

Thus, $V_{out} = \frac{Xc}{Xc+R} V$

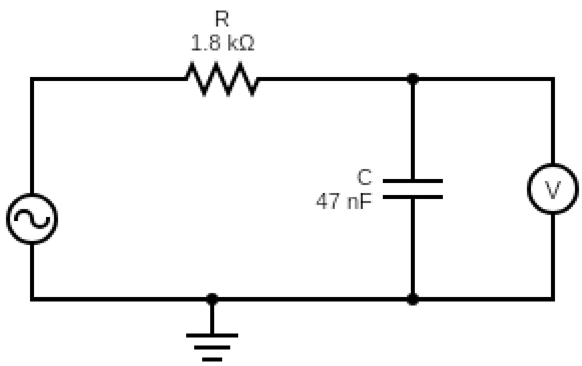
Implies, $V_{out} = \frac{1}{1+jwRC} V$

Therefore, Transfer Function, $H = \frac{1}{\sqrt{1+(wRC)^2}}$

For higher frequencies $\frac{V_{out}}{V}$ is very low, i.e. amplitude of output voltage gets attenuated at higher frequencies. Hence, this acts as a low-pass filter.

**Cut-off frequency** $W = \frac{1}{RC}$ (i.e. at this frequency the output power becomes half of the input power).

## ❖ Circuit Diagram:




## ❖ Observation:

For input voltage =10V(rms)

| Sl. No. | Frequency(Hz) | Magnitutude(dB) | Phase(theta) | Output Volt |
|---|---|---|---|---|
| 1 | 50 | -0.004 | -1.53 | 9.996 |
| 2 | 149 | -0.027 | -4.506 | 9.969 |
| 3 | 438 | -0.229 | -13.093 | 9.740 |
| 4 | 1294 | -1.675 | -34.468 | 8.246 |
| 5 | 1884.87 | -3 | -45 | 8.607 |
| 6 | 3818 | -7.075 | -63.746 | 4.428 |
| 7 | 11267 | -15.647 | -80.54 | 1.650 |
| 8 | 33252 | -24.941 | -86.799 | 0.566 |
| 9 | 98134 | -34.328 | -88.945 | 0.192 |
| 10 | 289614 | -43.727 | -89.673 | 0.065 |
| 11 | 854713 | -53.127 | -89.92 | 0.022 |
| 12 | 2522440 | -62.527 | -90.003 | 0.007 |

## ❖ Calculation:

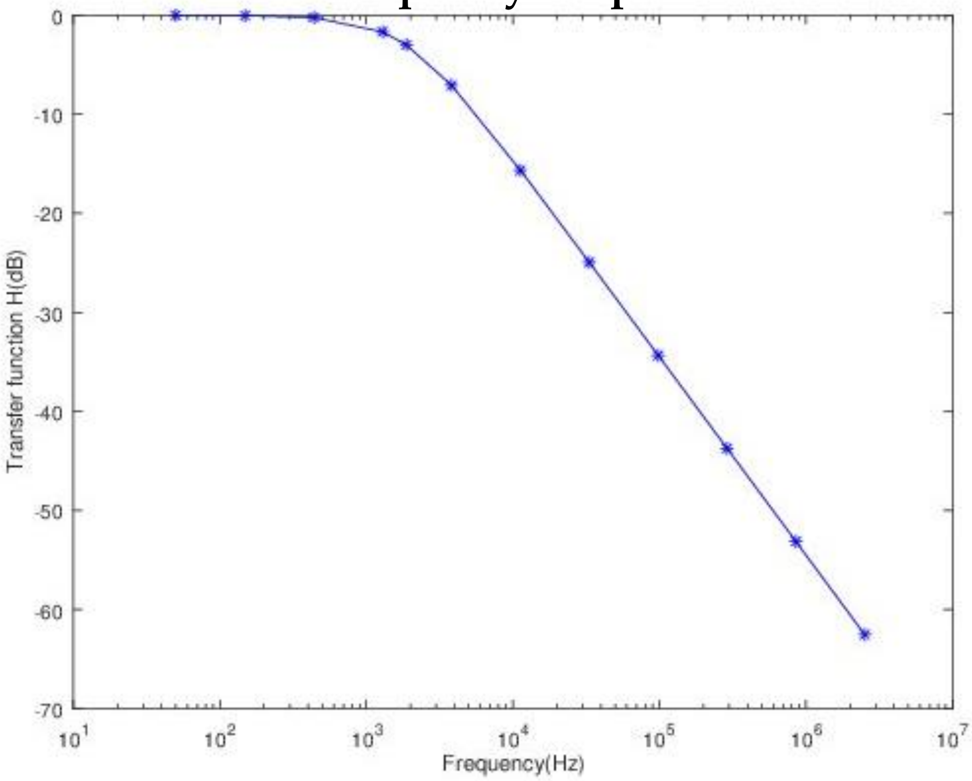
In our given circuit R=1.8kΩ and C=46.91nF.

Therefore, cut-off frequency w = $\frac{1}{RC}$ = 1884.87Hz.

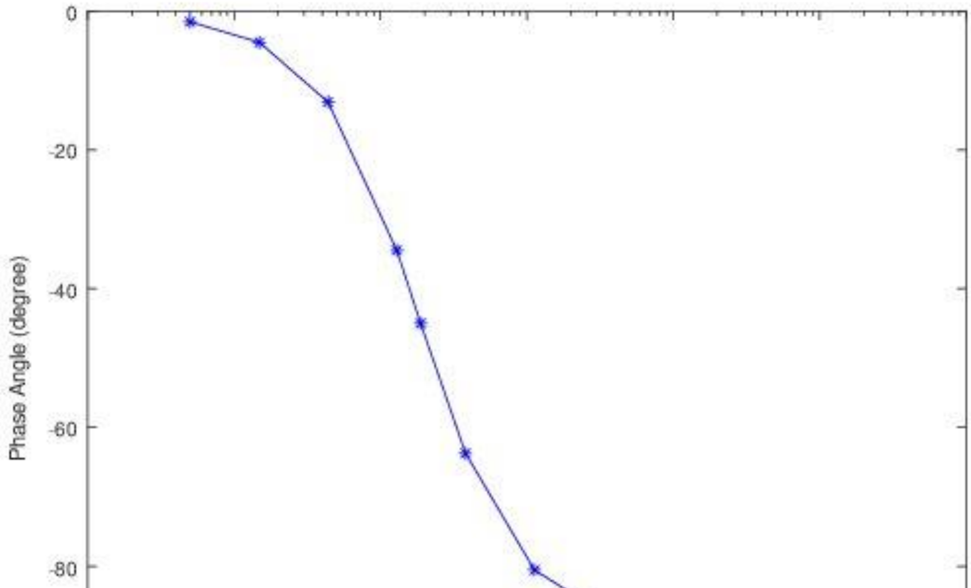
So, at this frequency H=-3dB.

## ❖ Plot:

**Frequency Response**




**Phase Response**



## ❖ Inference and discussion:

As evident from the above calculation and plot in this circuit, the signals with frequencies lower than 1884.87Hz will be allowed to pass and other higher frequencies will be blocked.

This circuit parameters can be varied to obtain a different cut-off frequency. So, any filter like this can be modelled according to our preference by choosing suitable resistance and capacitance.

## Part -II: R-C high pass filter

- Aim of the Experiment: To use R-C circuit as a high-pass filter and to observe its frequency response and phase response characteristics.

- Theory:

Input voltage of fixed magnitude $V_{in}$ (rms) is fed into simple series-RC circuit and output is taken from across the resistor.

Thus, $V_{out} = \frac{R}{Xc+R} V$

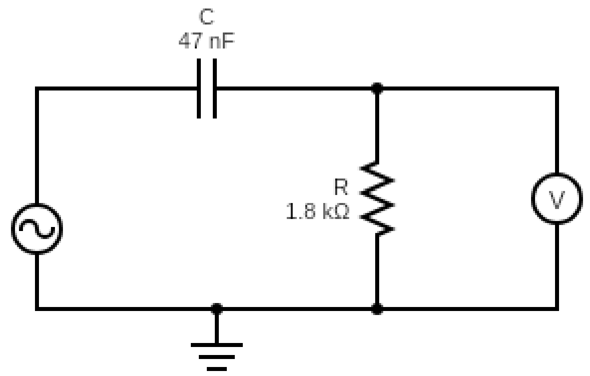
Implies, $V_{out} = \frac{1}{1+\frac{1}{jwRC}} V$

Therefore, Transfer Function, $H = \frac{1}{\sqrt{1+}}$

For lower frequencies $\frac{V_{out}}{V}$ is very low, i.e. amplitude of output voltage gets attenuated at lower frequencies. Hence, this acts as a high-pass filter.

**Cut-off frequency** $W = \frac{1}{RC}$ (i.e. at this frequency the output power becomes half of the input power).

- Circuit Diagram:




## ❖ Observation:

For input voltage =10V(rms)

| Sl. No. | Frequency(Hz) | Magnitutude(dB) | Phase(theta) | Output Volt |
|---|---|---|---|---|
| 1 | 50 | -31.477 | 88.516 | 0.26 |
| 2 | 149 | -22.101 | 85.54 | 0.78 |
| 3 | 438 | -12.902 | 76.953 | 2.26 |
| 4 | 1294 | -4.948 | 55.578 | 5.65 |
| 5 | 1884 | -3 | 45 | 8.60 |
| 6 | 3818 | -0.948 | 26.3 | 8.96 |
| 7 | 11267 | -0.12 | 9.506 | 9.86 |
| 8 | 33252 | -0.01395 | 3.248 | 9.98 |
| 9 | 98134 | -0.0016 | 1.1015 | 9.99 |
| 10 | 289614 | -0.0002 | 0.373 | 9.99 |
| 11 | 854713 | -2E-05 | 0.1265 | 10 |
| 12 | 2522440 | -2E-06 | 0.0429 | 10 |

## ❖ Calculation:

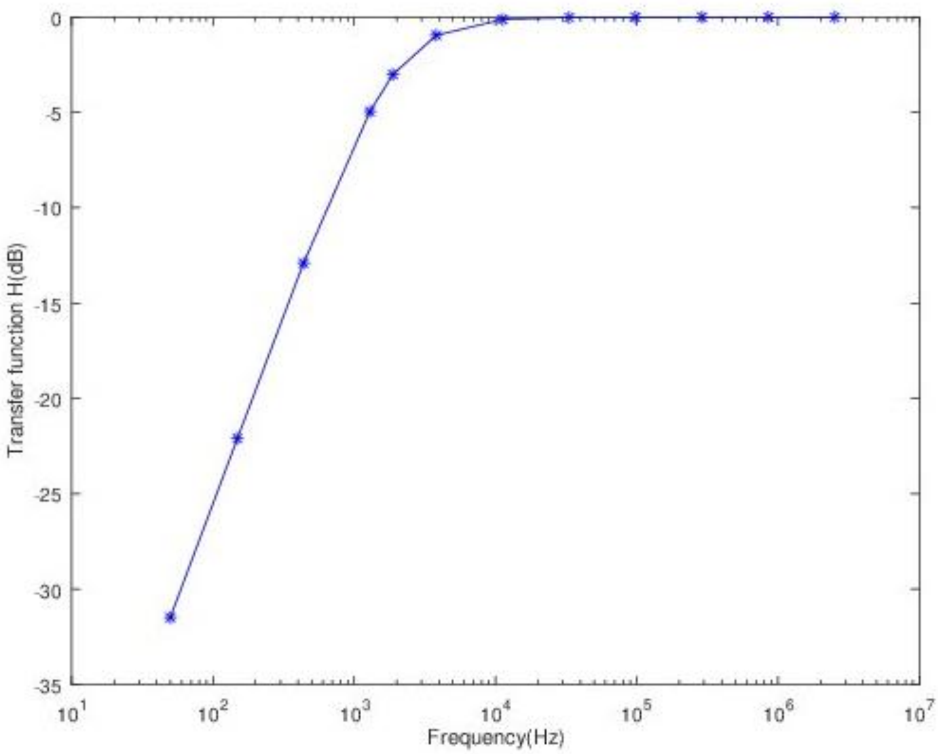
In our given circuit R=1.8kΩ and C=46.91nF.

Therefore, cut-off frequency w = $\frac{1}{RC}$ = 1884.87Hz.

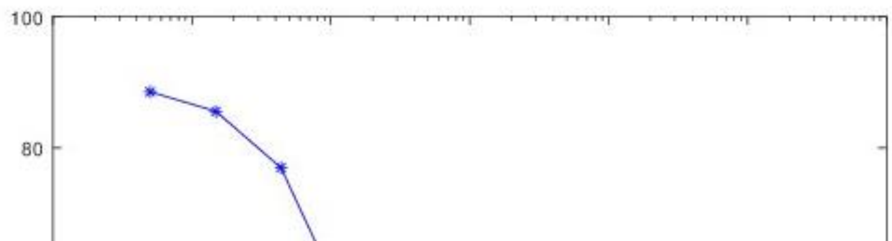
So, at this frequency H=-3dB.

❖ Plot:

**Frequency Response**




**Phase Response**



## ❖ Inference and discussion:

As evident from the above calculation and plot in this circuit, the signals with frequencies higher than 1884.87Hz will be allowed to pass and other lower frequencies will be blocked.

This circuit parameters can be varied to obtain a different cut-off frequency. So, any filter like this can be modelled according to our preference by choosing appropriate resistance and capacitance values.

## Part -III: R-L low pass filter

- Aim of the Experiment: To use R-L circuit as a low-pass filter and to observe its frequency response characteristics.

- Theory:

Input voltage of fixed magnitude $V_{in}$ (rms) is fed into simple series-RL circuit and output is taken from across the resistor.

Thus, $V_{out} = \frac{R}{X_L + R} V$

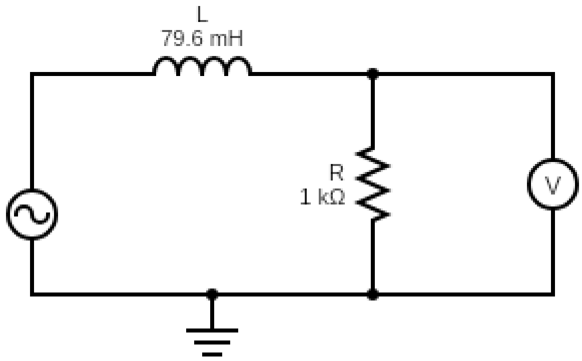
Implies, $V_{out} = \frac{1}{1+\frac{jwL}{R}} V$

Therefore, Transfer Function, $H = \frac{1}{\sqrt{1+\left(\frac{wL}{R}\right)^2}}$

For higher frequencies $\frac{V_{out}}{V}$ is very low, i.e. amplitude of output voltage gets attenuated at higher frequencies. Hence, this acts as a high-pass filter.

**Cut-off frequency** $W = \frac{R}{L}$,(i.e. at this frequency the output power becomes half of the input power).

- Circuit Diagram:




## ❖ Observation:

For input voltage =10V(rms)

| Sl. No. | Frequency(Hz) | Magnitutude(dB) |
|---|---|---|
| 1 | 50 | 0 |
| 2 | 15.41 | -0.02 |
| 3 | 452.62 | -0.22 |
| 4 | 1200 | -1.33 |
| 5 | 2000 | -3 |
| 6 | 3600 | -6.27 |
| 7 | 5020 | -8.53 |
| 8 | 7010 | -11.23 |
| 9 | 10070 | -14.21 |
| 10 | 19900 | -20 |

## ❖ Calculation:

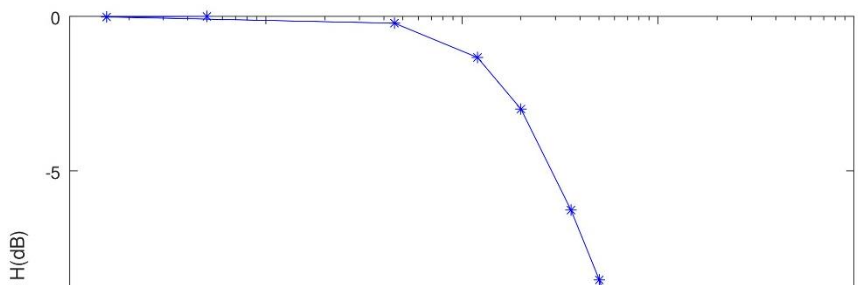
In our given circuit R=1kΩ and L=79.58mH.

Therefore, cut-off frequency w = $\frac{R}{L}$ = 1999.97Hz = 2kHz (approx.)

So, at this frequency H=-3dB.

## ❖ Plot:

**Frequency Response**



## ❖ Inference and discussion:

As evident from the above calculation and plot in this circuit, the signals with frequencies lower than 2000Hz will be allowed to pass and other higher frequencies will be blocked.

This circuit parameters can be varied to obtain a different cut-off frequency. So, any filter like this can be modelled according to our requirement by choosing appropriate resistance and inductance values.

## Part -IV: R-L high pass filter

- Aim of the Experiment: To use R-L circuit as a high-pass filter and to observe its frequency response characteristics.

- Theory:

Input voltage of fixed magnitude $V_{in}$ (rms) is fed into simple series-RL circuit and output is taken from across the inductor.

Thus, $V_{out} = \frac{X_L}{X_L+R} V$

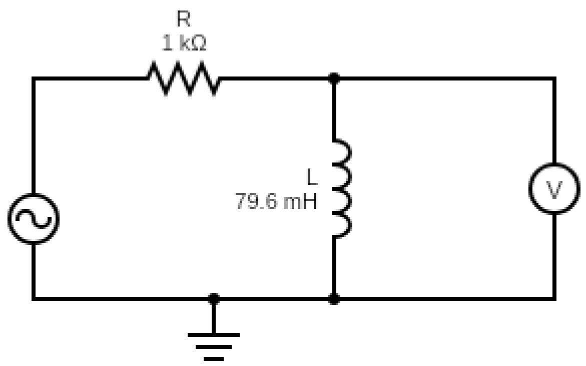
Implies, $V_{out} = \frac{1}{1+\frac{R}{jwL}} V$

Therefore, Transfer Function, $H = \frac{1}{\sqrt{1+\left(\frac{R}{wL}\right)^2}}$

For lower frequencies $\frac{V_{out}}{V}$ is very low, i.e. amplitude of output voltage gets attenuated at lower frequencies. Hence, this acts as a high-pass filter.

**Cut-off frequency** $W = \frac{R}{L}$,(i.e. at this frequency the output power becomes half of the input power).

- Circuit Diagram:


R
1 kΩ
L
79.6 mH
V

## ❖ Observation:

For input voltage =10V(rms)

| Sl. No. | Frequency(Hz) | Magnitutude(dB) |
|---|---|---|
| 1 | 50.3 | -32.04 |
| 2 | 151.66 | -22.43 |
| 3 | 428 | -13.59 |
| 4 | 1100 | -6.35 |
| 5 | 2000 | -3 |
| 6 | 3750 | -1.09 |
| 7 | 5000 | -0.65 |
| 8 | 7020 | -0.35 |
| 9 | 10080 | -0.17 |
| 10 | 20000 | -0.04 |

## ❖ Calculation:

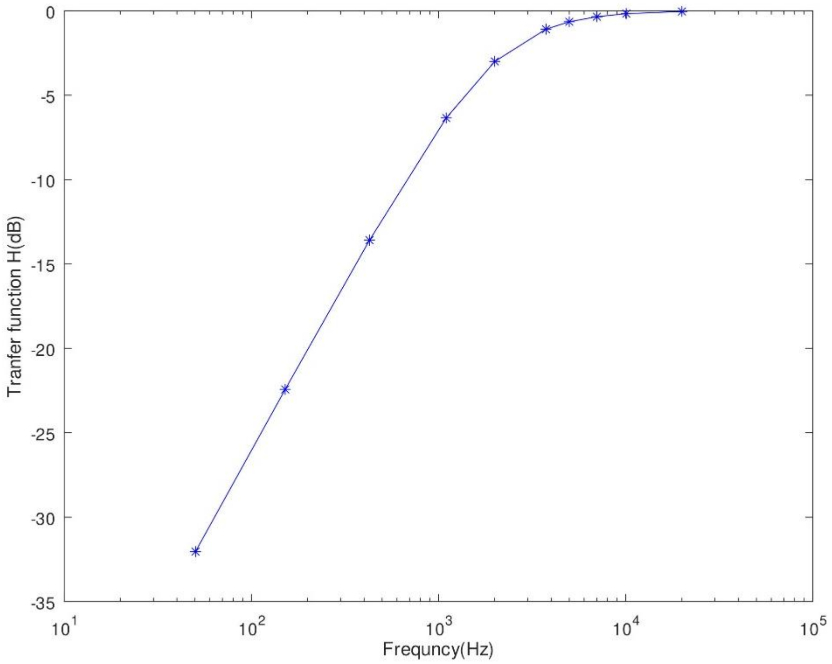
In our given circuit R=1kΩ and L=79.58mH.

Therefore, cut-off frequency w = $\frac{R}{L}$ = 1999.97Hz = 2kHz (approx.)

So, at this frequency H=-3dB.

❖ Plot:

**Frequency Response**




## ❖ Inference and discussion:

As evident from the above calculation and plot in this circuit, the signals with frequencies higher than 2000Hz will be allowed to pass and other lower frequencies will be blocked.

This circuit parameters can be varied to obtain a different cut-off frequency. So, any filter like this can be modelled according to our requirement by choosing appropriate resistance and inductance values.

***Discussion*** *: Filters are electronic circuits that remove any unwanted components or features from a signal. In simple words, you can understand it as the circuit rejects certain band of frequencies and allows others to pass through. They are widely used in Instrumentation, Electronics and Communication Systems especially in Signal and Image processing systems.*

*Though practically, there does not exist a single cut-off frequency, Vout/Vin actually have a continuous graph, the output considered to be zero when falls below a certain value (commonly the half power value).*

*Different Applications of passive filter circuits include:*

- *Filter Circuits are used to eliminate background Noise*
- *They are used in Radio tuning to a specific frequency*
- *Used in Pre-amplification, Equalization, Tone Control in Audio Systems*
- *They are also used in Signal Processing Circuits and Data Conversion*
- *Filter Circuits are extensively used in Medical Electronic Systems*

***Reference :*** *All the above data and plots done in falstad.com circuit simulator can be seen here.*

*Part1 :*

*RC low pass filter*

*Part2 :*

*RC high pass filter*

*Part3 :*

*RL low pass filter*

*Part4 :*

*RL high pass filter*